Proceeding of the International Conference on Global Education and Learning
Volume. 1, Number. 2, Year 2024
e-ISSN : 3089-8072, Page 115-130
Available online at: https://prosiding.aripi.or.id/index.php/ICGEL

The Role of Scaffolding Assessment in Support of Self-Directed Learning in a Project-Based Learning of Research Class

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Abstract: *This study investigates the role of scaffolding assessment in fostering self-directed learning (SDL) within project-based learning (PBL) environments in higher education. Scaffolding assessment, characterized by gradual guidance, helps students transition from structured support to greater autonomy while enhancing critical thinking, goal-setting, and self-regulation. Through a mixed-methods approach, the study examines students' perceptions and experiences of scaffolding interventions in a research-based course. Quantitative findings reveal positive impacts on autonomy, critical thinking, and goal-setting, while qualitative insights highlight the importance of tailored scaffolding tools, motivational elements, and digital adaptability.Although scaffolding significantly enhances SDL by promoting independence and cognitive engagement, challenges remain in optimizing digital tools and addressing individual learning needs. Personalized scaffolding strategies and motivational scaffolds are essential for sustaining long-term engagement and effectively supporting diverse learners in complex, research-intensive environments. This study underscores the importance of adaptive scaffolding designs that balance structure and flexibility, offering practical implications for educators seeking to implement scaffolding assessments to enhance student autonomy and learning outcomes in higher education.*

Keywords: *Scaffolding Assessment, Research Class, Higher Education, Student Autonomy*.

1. INTRODUCTION

Self-directed learning has become increasingly important in higher education, particularly due to its ability to develop student autonomy and essential problem-solving skills in the modern world. Problem-based learning approaches, for example, not only support the development of problem-solving abilities but also promote autonomous learning, enabling students to process and manage information independently (Karaoğlan Yılmaz, 2021; Matsuba et al., 2023). Moreover, higher education encourages the mastery of lifelong learning by equipping students with skills that will support their future professional development, bolster confidence, and foster independence in the learning process (Rascón-Hernán et al., 2019; Ryan, 1993). In the context of online learning, students can more readily develop their learning autonomy because they have greater control over their time and learning resources, which has proven particularly beneficial during the pandemic (Shin & Kim, 2020; Robertson, 2011). Through self-directed learning, students not only become more autonomous but are also prepared to actively participate in society and cultivate greater social responsibility, making them more empowered and responsible lifelong learners (Shin & Kim, 2020; Aljafari, 2021).

As part of the gradual support provided through scaffolding, this assessment plays a crucial role in guiding students toward greater independence in their learning practices. By offering structural and incremental support, scaffolding assessments help students gradually transition from dependence on the instructor to learning autonomy, particularly in complex

Received: October30, 2024; Revised: November 30, 2024; Accepted: December 18,2024; Published: December 30, 2024

learning environments such as research-based project classes. Research shows that scaffolding assessments are effective in enhancing students' problem-solving skills and enabling them to develop a deeper conceptual understanding. For instance, in research projects, scaffolding has been proven to assist students in achieving higher independence in their learning processes by supporting the development of self-regulation skills needed to manage the complexity of projects independently (Padmadewi et al., 2023; Dijk & Lazonder, 2016; Puntambekar & Hubscher, 2005). In challenging project-based environments, well-designed scaffolded support allows students to develop critical self-regulation skills to manage project complexity more independently, thereby reinforcing their learning autonomy (Mamun, Lawrie, & Wright, 2020; Erdei, Springer, & Whittinghill, 2017).

As a continuation of the importance of scaffolding in education, project-based learning (PBL) also plays a significant role in fostering critical thinking and problem-solving skills among students, particularly in research-oriented environments. In PBL, students are empowered to confront and solve real-world problems, which require them to think critically and apply their knowledge in practical, real-life contexts. Research indicates that this approach not only enhances students' understanding but also strengthens their ability to engage in systemic thinking and solve complex problems relevant to real-life situations (Nagarajan & Overton, 2019; Kłeczek et al., 2020). Furthermore, PBL enables students to develop profound problem-solving skills while fostering motivation and a deeper understanding of the material through its application in real-world scenarios, making it an effective strategy for long-term learning (Massa et al., 2008; McKinney, 2023).

Studies have shown that scaffolding can reinforce students' self-directed learning by providing tools to help them manage their learning processes more independently. Personalized scaffolding, such as tailored recommendations for specific learning goals, has been demonstrated to improve achievement and self-regulation skills, enabling students to acquire new skills independently over time (Ley et al., 2010; Mamun et al., 2020). In e-learning environments, scaffolding that incorporates metacognitive support has also been shown to significantly enhance academic self-efficacy and learning outcomes, allowing students to develop better self-regulation skills in the process of independent learning (Valencia-Vallejo et al., 2018; Lin et al., 2016).

In project-based learning environments, scaffolding plays a crucial role by providing gradually reduced support to encourage students to take control of their own learning processes. This approach, known as "fading," enables students to progressively develop independence in solving complex problems, aligning with the objectives of self-directed learning. Studies

suggest that gradually reducing support helps students build critical thinking and self-regulation skills in complex learning environments, such as project-based classes (Dabbagh, 2003; Puntambekar & Hubscher, 2005). Thus, scaffolding not only assists students in overcoming academic challenges but also prepares them to become more autonomous learners in the future (Mamun et al., 2020).

Previous research has extensively explored the role of scaffolding in project-based learning environments with an emphasis on self-directed learning. For example, a study by Dijk and Lazonder (2016) demonstrated that technology-based scaffolding can enhance students' conceptual understanding through the use of supportive tools in inquiry-based science learning environments (Dijk & Lazonder, 2016). Similarly, another study by Mamun, Lawrie, and Wright (2020) highlighted how scaffolding strategies in online learning modules support student engagement in self-directed learning, creating a learning design that fosters student autonomy in project-based environments (Mamun et al., 2020).

Additionally, research by Simons and Klein (2007) demonstrates that tailored scaffolding, whether optional or mandatory support, in problem-based learning environments leads to improved student performance in complex group projects (Simons & Klein, 2007). These studies emphasize the critical role of scaffolding in fostering students' critical thinking and self-regulation skills.

However, despite the wealth of research highlighting the benefits of scaffolding in supporting self-directed learning, a research gap remains regarding the specific implementation of scaffolding in the form of assessments within research-oriented, project-based learning environments. Existing literature has yet to comprehensively explore how scaffolding assessments can be optimally designed and applied to support students' transition toward independent learning, particularly in research-focused classrooms.

Hence, *this study aims to provide insights into how scaffolding assessment supports self-directed learning among students and improves research project outcomes in a structured, research-based learning environment.* By examining students' perceptions and experiences, this study seeks to identify effective scaffolding strategies that contribute to greater independence in learning. This research will contribute to the existing body of knowledge by illustrating how scaffolding can be applied effectively to foster student autonomy. Moreover, it provides practical implications for educators seeking to implement scaffolding assessments that encourage self-directed learning in higher education settings, particularly in project-based courses.

2. LITERATURE REVIEW

The Concept of Scaffolding in Education

Scaffolding is recognized as an educational method that provides gradual support to students, which diminishes as their ability to complete tasks independently increases. According to Vygotsky's (1978) theory of the Zone of Proximal Development (ZPD), optimal learning occurs when students are guided just beyond their current level of competence, enabling them to progress toward independent understanding (Vygotsky, 1978). Wood, Bruner, and Ross (1976) further explained that scaffolding serves as a bridge that helps students access new knowledge and skills independently, allowing them to develop a deep understanding, critical thinking skills, and confidence in tackling complex tasks (Wood, Bruner, & Ross, 1976).

Scaffolding assessment refers to an approach where feedback and guidance are gradually provided to encourage students to achieve their full potential while fostering independence. García-Jiménez et al. (2015) found that structured feedback within scaffolding assessment helps students independently identify and correct errors, strengthening their self-regulation skills (García-Jiménez et al., 2015). Similarly, Beaumont et al. (2016) highlighted the importance of dialogic feedback in supporting students' transition to self-directed learning by deepening conceptual understanding and enhancing their confidence (Beaumont et al., 2016).

The primary goal of scaffolding assessment is to support student autonomy, enabling them to manage their learning processes independently. Costelloe and Egan (2020) emphasized that scaffolding in the form of self-assessment and peer assessment enhances evaluative and reflective skills, which are critical in higher education (Costelloe & Egan, 2020). By addressing not only cognitive aspects but also emotional and motivational regulation, scaffolding assessment holistically reinforces students' self-directed learning capabilities.

Despite the significant potential of scaffolding assessment in fostering learning autonomy, the literature on its specific application in project-based learning (PBL) and research-oriented contexts in higher education remains limited. While many studies examine scaffolding's role in self-directed learning and critical thinking skills, few delve into the optimal implementation of scaffolding in more complex, project-based assessment environments. Further research is needed to explore how scaffolding assessment can be adapted to help students transition toward independence in challenging, project-based educational settings.

Project-Based Learning (PBL)

Project-based learning (PBL) is an effective approach for developing critical thinking and problem-solving skills, particularly in research-oriented environments. PBL enables students to apply theoretical knowledge to practical tasks, deepening their understanding while enhancing collaborative skills. According to Dutta et al. (2022), PBL increases student engagement and autonomy in completing complex tasks that resemble real-world situations (Dutta et al., 2022).

PBL provides opportunities for students to design and execute research projects, thereby enhancing their analytical, communication, and teamwork skills. Li (2015) emphasized that PBL encourages the transformation of students into active learners, improving their research and problem-solving abilities in higher education (Li, 2015). Direct research experiences through PBL have been shown to positively impact students' career readiness, equipping them with relevant professional skills.

Although PBL is effective in fostering critical thinking and problem-solving skills, further research is needed to understand its optimal application in research-oriented classrooms. The current literature is limited in exploring the best strategies for adapting PBL to support the development of research skills in environments focused on inquiry and investigation.

By examining the interplay between scaffolding assessment and PBL, future studies can contribute valuable insights into designing effective educational practices that promote student autonomy and research competency. This exploration is essential for enhancing learning outcomes in research-based, project-driven educational contexts.

Scaffolding Assessment and Its Role in Supporting Self-Directed Learning (SDL)

Scaffolding assessment supports self-directed learning (SDL) by providing gradual guidance that enables students to independently manage their learning processes. Hmelo-Silver et al. (2007) found that scaffolding in PBL and inquiry-based learning reduces students' cognitive load, thereby enhancing their ability to control their own learning processes (Hmelo-Silver et al., 2007).

Mamun et al. (2020) demonstrated that technology-based scaffolding in online environments helps students independently access and utilize resources, thereby strengthening their autonomy (Mamun et al., 2020). PBL inherently encourages students to plan and execute projects independently, and scaffolding assessment plays a crucial role in supporting SDL in this context. Research by Bagheri et al. (2013) revealed that students who received scaffolding assessment in PBL exhibited significantly improved SDL skills

compared to those in traditional teaching methods, highlighting the importance of incremental assessment in facilitating the transition to independent learning (Bagheri et al., 2013).

Despite the substantial body of research showcasing the benefits of scaffolding in supporting SDL within PBL environments, gaps remain regarding the most effective scaffolding methods for complex projects. Further studies are needed to explore optimal scaffolding strategies that can help students achieve higher SDL skills in the context of intensive research and project-based learning.

By addressing these gaps, future research can enhance understanding of how scaffolding assessment can be designed and applied to equip students with advanced SDL skills, particularly in complex and research-oriented learning environments.

3. METHODOLOGY

This study adopted a mixed-methods approach to examine the effectiveness of scaffolding assessment in fostering self-directed learning (SDL) within a project-based learning framework in a research course. By combining quantitative and qualitative data collection methods, the research aimed to provide a comprehensive understanding of how scaffolding interventions influence autonomy, goal setting, critical thinking, adaptability, and motivation. A convergent parallel mixed-methods design was employed, with data collected simultaneously through a structured questionnaire and in-depth interviews. The questionnaire provided numerical insights into students' perceptions of scaffolding, while the interviews offered detailed qualitative reflections.

The participants comprised 34 undergraduate students enrolled in a research class that implemented project-based learning. Selected through purposive sampling, the participants represented diverse academic disciplines, including social sciences, engineering, and education, and ranged in age from 19 to 25 years. An equal distribution of male and female students ensured balanced representation. Participation in the study was voluntary, and informed consent was obtained from all individuals involved.

This study's key aspects of self-directed learning (SDL)—autonomy, goal setting, critical thinking, adaptability, motivation, tailored teaching, and active engagement—were constructed based on established theoretical frameworks and prior research. Autonomy, for instance, draws on Grow's (1991) staged self-directed learning model, which emphasizes the progressive development of independence through guided support. Goal setting and self-monitoring are informed by Zimmerman and Schunk's (2017) work on self-regulation, which

highlights the importance of structured frameworks for defining and tracking objectives. Critical thinking and reflection align with the work of Bransford et al. (2000), emphasizing scaffolding as a tool to deepen cognitive engagement. Adaptability and digital skills incorporate findings from Morris (2019) and Sung et al. (2017), which focus on the integration of digital tools and flexible learning pathways to meet diverse needs. Motivation is grounded in Garrison's (1997) model of SDL, emphasizing the role of scaffolding in maintaining learners' focus and engagement. Finally, the tailored teaching aspect draws from Dabbagh et al. (2016) and Puntambekar et al. (2020), advocating for personalized scaffolding approaches to align with individual learners' contexts. These theoretical foundations ensured that the study's aspects were robust, comprehensive, and relevant to assessing scaffolding in project-based learning.

The structured questionnaire consisted of 21 items rated on a 4-point Likert scale (1 = Strongly Disagree, 4 = Strongly Agree). The questionnaire was piloted with a small group of students to ensure clarity and reliability before full deployment. Data collected from the questionnaire were analyzed using descriptive statistics, calculating mean scores and standard deviations for each dimension.To complement the quantitative data, in-depth semi-structured interviews were conducted with 15 participants from the same cohort. The interviews explored students' perspectives on the impact of scaffolding assessment on their SDL skills and their overall learning experience. Open-ended questions allowed participants to elaborate on their experiences, such as how scaffolding influenced their ability to manage research projects, set goals, engage in reflective thinking, and maintain motivation. The interviews were audio-recorded, transcribed verbatim, and analyzed thematically to identify recurring patterns and themes.

Quantitative data were analyzed descriptively to identify trends and variations across SDL dimensions. Mean scores were calculated for each questionnaire item, and dimensions with scores below 3.0 were flagged for further analysis. Thematic analysis of the interview transcripts involved coding responses to identify key themes, including autonomy, goal setting, critical thinking, adaptability, and motivation. Representative quotes were selected to provide contextual depth to the findings. During interpretation, the results from the quantitative and qualitative analyses were integrated to create a holistic understanding of scaffolding's role in fostering SDL. Quantitative data highlighted general trends, while qualitative responses provided nuanced insights into students' experiences and challenges.

Ethical approval for the study was obtained from the university's research ethics committee. All participants were informed about the study's objectives, their right to withdraw at any time, and the confidentiality of their responses. Anonymity was ensured by assigning unique codes to participants during data analysis and reporting. Despite the strengths of this approach, certain limitations were acknowledged. The relatively small sample size limits the generalizability of the findings, and the reliance on self-reported data may introduce bias. Future research could expand on these findings through larger samples and longitudinal studies to explore the long-term impacts of scaffolding on SDL. This rigorous methodology provides a balanced and reliable foundation for examining the effectiveness of scaffolding assessment in project-based learning contexts.

Findings

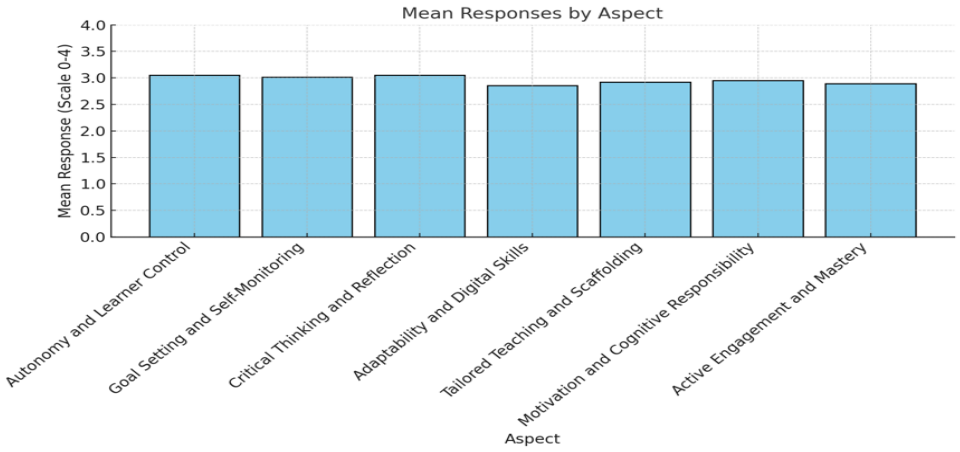
This study examined the effectiveness of scaffolding assessment in fostering self-directed learning (SDL) among students engaged in project-based learning within a research class. To gain a comprehensive understanding, the study employs a mixed-methods approach, utilizing both quantitative and qualitative data collection methods. The questionnaire serves as the primary quantitative instrument, capturing students' perceptions and experiences of scaffolding in relation to SDL skills such as autonomy, goal setting, critical thinking, adaptability, and motivation. Complementing this, in-depth interviews provide qualitative insights into students' personal experiences and reflections on the scaffolding interventions.

Quantitative Results

The analysis of the questionnaire responses highlights the role of scaffolding assessment in supporting students' self-directed learning (SDL) within the framework of project-based learning. The findings provide a quantitative overview of how scaffolding interventions influenced key aspects of the learning process, including autonomy, goal setting, critical thinking, adaptability, and motivation. Responses were consistently positive across these dimensions, reflecting students' appreciation of scaffolding as a supportive tool for navigating the complexities of research projects.

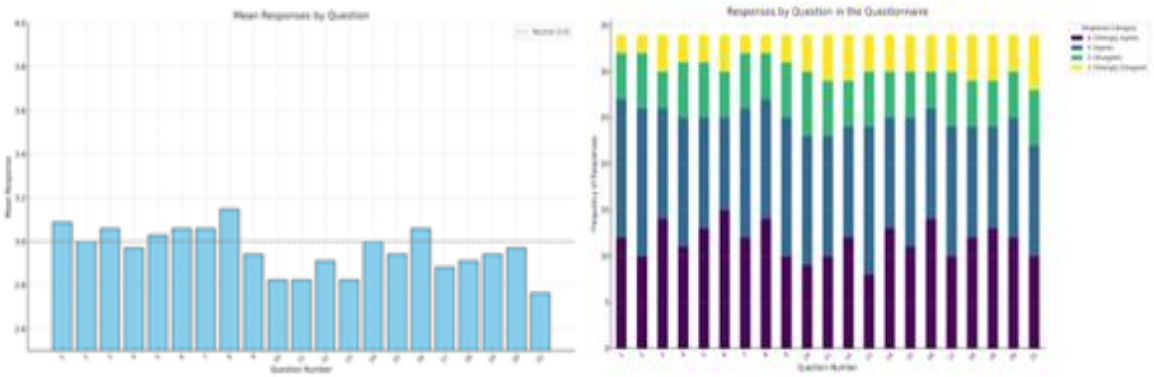
The study utilized a structured questionnaire with 21 items, each designed to measure specific aspects of SDL. Responses were collected from 34 students enrolled in a research course, with a focus on their experiences during the development of research proposals. The questionnaire measured the perceived effectiveness of scaffolding in enhancing autonomy, promoting reflection, and fostering engagement. The analysis

revealed consistent patterns of satisfaction, with most responses indicating agreement or strong agreement with the effectiveness of scaffolding interventions.



The analysis of questionnaire responses highlights that scaffolding assessment generally has a positive impact on fostering self-directed learning (SDL) among students. Across the various aspects evaluated, mean scores ranged from 2.89 to 3.05 on a 4-point Likert scale, indicating overall satisfaction with the scaffolding interventions. Most responses were above the neutral threshold of 3.0, suggesting that students perceived the scaffolding tools as effective in supporting their learning processes, particularly in areas like autonomy and critical thinking.

The aspect-level analysis revealed key strengths in areas such as "Autonomy and Learner Control" and "Critical Thinking and Reflection," both achieving the highest average score of 3.05. Students reported that scaffolding provided them with clear initial guidance and boosted their confidence in making independent decisions regarding their learning processes. Similarly, aspects like "Goal Setting and Self-Monitoring" (mean: 3.02) were perceived as helpful in equipping students with tools to set and track progress effectively. Conversely, areas like "Adaptability and Digital Skills" (mean: 2.85) and "Active Engagement and Mastery" (mean: 2.89) scored slightly lower, suggesting that digital scaffolding tools and activities promoting the application of theoretical knowledge could be further optimized to meet learners' needs.



The distribution of responses across the questionnaire revealed interesting patterns. For most questions, the majority of students responded with "Agree" or "Strongly Agree," indicating widespread satisfaction with scaffolding activities. However, a small subset of responses reflected variability in specific areas, such as the adaptability of scaffolding to individual needs and the practical application of theoretical concepts. These findings align with the mean scores for individual questions, which varied between 2.85 and 3.1. Questions related to autonomy, critical thinking, and reflection received higher ratings, while those targeting digital adaptability and practical application tended to have lower averages.

In terms of question-level analysis, questions focused on enabling autonomy, such as those addressing topic selection and timeline management, consistently received mean scores above 3.0. Similarly, questions emphasizing critical thinking and reflective activities also performed well, with mean scores ranging from 3.0 to 3.05. On the other hand, questions targeting the effectiveness of digital scaffolding tools and individual tailoring of scaffolding interventions received lower mean scores, reflecting the need for more personalized and intuitive solutions in these areas.

Overall, scaffolding assessments were effective in supporting autonomy, critical thinking, and goal-setting, crucial components of SDL. However, the findings also highlight areas for improvement, such as refining digital tools and tailoring scaffolding interventions to individual learning contexts. By addressing these gaps, educators can further enhance the effectiveness of scaffolding strategies, ensuring a comprehensive approach to nurturing independent and capable learners.

Qualitative Result

The analysis of the interview responses revealed a set of interconnected themes highlighting the role of scaffolding in fostering self-directed learning (SDL). These themes encompass autonomy, goal setting, critical thinking, adaptability, motivation, and tailored teaching. The findings illustrate how scaffolding tools and practices impacted students' learning processes, their perceptions of independence, and their engagement with research tasks. Each theme captures unique dimensions of the scaffolding experience, supported by participant quotes and qualitative patterns. The data were derived from 15 in-depth interviews with undergraduate students across various disciplines, including social sciences, engineering, and education. Participants ranged in age from 19 to 25 years and were evenly distributed across genders. The interviews were structured around open-ended questions addressing scaffolding experiences, such as autonomy, progress tracking, and

digital adaptability. Data collection focused on uncovering how scaffolding facilitated or hindered their learning journey.

Scaffolding significantly enhanced autonomy and learner control, with many participants expressing that scaffolding tools provided clear guidance while fostering independence. One participant shared, *"The scaffolding gave me confidence to choose a topic I was passionate about, but I appreciated having a framework to follow."* Another echoed, *"At first, I needed a lot of support, but as I progressed, I could handle decisions on my own."* These responses demonstrate that scaffolding helps students transition from guided learning to autonomous decision-making. However, a few participants noted that too much scaffolding early on limited their creativity, suggesting a balance is necessary to empower autonomy without over-structuring.

Goal setting and progress monitoring emerged as critical aspects supported by scaffolding. Tools like worksheets and checklists were praised for helping students organize and track their research. One participant explained, *"The progress log made it easy to see how far I'd come and what was left to do."* Another participant mentioned, *"The checklist kept me on track weekly, even when I felt overwhelmed by the bigger project."* Despite these positives, some students struggled with consistency, with one admitting, *"I often forgot to update my log, which made it harder to reflect later."* These findings indicate that scaffolding tools need to be both intuitive and adaptable to encourage regular usage.

Critical thinking and reflective practices were highly valued, with participants highlighting the impact of scaffolding on their ability to analyze challenges and refine their approaches. One participant stated, *"The problem-solving templates helped me break down complex issues into manageable parts."* Another shared, *"Reflective prompts pushed me to think about what I could improve in my methods."* However, not all experiences were positive. A few participants felt that reflective tasks were repetitive, with one noting, *"It felt like I was answering the same questions over and over."* This suggests that while scaffolding is effective in fostering critical thinking, it should be designed to avoid redundancy.

Adaptability and digital skills represented an area with mixed feedback. Participants appreciated being introduced to digital tools but often required additional resources to fully master them. One student remarked, *"I learned the basics of the software, but I had to search online tutorials to understand it better."* Another added, *"The scaffolding helped me explore new tools, but it didn't show how to apply them to my specific project."* These

responses highlight the need for scaffolding to provide more practical, hands-on training tailored to individual research needs.

Motivation and engagement were closely tied to scaffolding, with participants noting its role in maintaining focus and momentum. One student stated, *"The step-by-step tasks motivated me to keep going because they didn't feel overwhelming."* Another shared, *"Knowing there was a structure made me feel supported, especially during challenging phases."* However, a few participants struggled with long-term motivation, with one explaining, *"The scaffolding worked well for small goals, but I still felt lost about the bigger picture."* This underscores the importance of balancing short-term strategies with long-term scaffolding support.

Tailored teaching and practical application emerged as recurring themes, with participants expressing the need for more personalized scaffolding tools. One participant stated, *"The templates were a good starting point, but I had to make significant adjustments to fit my topic."* Another explained, *"Some tools felt too generic and didn't align with the specific challenges of my research."* These responses indicate that scaffolding interventions should be more flexible and responsive to diverse learner needs.

In conclusion, scaffolding plays a critical role in fostering autonomy, critical thinking, and goal-setting, all key components of SDL. However, the findings highlight areas for improvement, including enhancing digital support, refining reflective tasks, and providing more personalized scaffolding strategies. By addressing these gaps, educators can optimize scaffolding interventions to better meet the diverse needs of learners and promote more effective self-directed learning outcomes.

4. DISCUSSION

The integration of scaffolding into project-based learning (PBL) (Kanzunnudin, 2011) within research classes significantly enhances self-directed learning (SDL) by supporting autonomy, critical thinking, and goal-setting while identifying areas for improvement. Both quantitative and qualitative analyses provide insights into the multifaceted impact of scaffolding on students' learning

Scaffolding interventions effectively promote autonomy, enabling students to take control of their learning processes. Participants reported confidence in making independent decisions while benefiting from structured guidance. These findings align with prior research emphasizing that scaffolding supports learner autonomy by gradually reducing assistance as learners gain proficiency (Dabbagh, 2003). Furthermore, incorporating autonomy into SDL

tools enhances students' motivation and ownership of tasks (Kim, 2019). Next, Reflective scaffolding tools, such as problem-solving templates and progress logs, improve students' critical thinking by breaking complex tasks into manageable parts. However, some students found reflective tasks repetitive, indicating a need for dynamic scaffolding that avoids redundancy (Hmelo-Silver et al., 2007). Scaffolding strategies that balance structure and adaptability enable learners to refine their methods and foster deeper analytical skills (Mamun et al., 2020). **Besides,** Tools like checklists and worksheets were well-received for helping students organize and track progress, supporting findings that structured scaffolding enhances SDL by facilitating task segmentation and long-term goal alignment (Petersen, 2016). However, variability in tool usage points to the need for personalized scaffolding strategies that cater to individual student needs (Simons & Klein, 2007).

Moreover, While digital tools provide opportunities for SDL, participants highlighted challenges in mastering and applying these technologies effectively. Findings suggest a need for practical, hands-on scaffolding for digital skill development to ensure inclusivity and efficacy (Quintana & Aguinaga, 2022). Enhanced scaffolding strategies must include training and intuitive designs to support diverse learning contexts (Van Uum et al., 2017). Next, The stepwise structure of scaffolding interventions promotes short-term engagement and long-term learning outcomes. However, some students reported difficulties sustaining motivation for larger projects, highlighting the importance of integrating motivational scaffolds that bridge immediate tasks and overarching goals (Peng et al., 2022). Finally, Tailored scaffolding strategies are essential to address the diverse learning needs of students. Generic tools often fail to align with specific research challenges, emphasizing the value of adaptive scaffolding systems (Ley et al., 2010). Personalized approaches, informed by student feedback and learning analytics, could significantly enhance scaffolding efficacy (Mamun et al., 2020).

Scaffolding plays a pivotal role in supporting SDL by fostering autonomy, critical thinking, and engagement within PBL contexts. However, areas like digital adaptability and personalization require refinement to maximize its benefits. Future research should explore innovative scaffolding designs that balance structure and flexibility to meet diverse learner needs effectively.

5. CONCLUSION

Scaffolding assessment is a critical educational strategy that effectively supports self-directed learning (SDL) by providing structured guidance that gradually transitions students toward greater autonomy. Within project-based learning (PBL) contexts, scaffolding fosters

essential skills such as autonomy, critical thinking, and goal-setting, enabling students to independently manage complex academic tasks. This study highlights the role of scaffolding tools—such as checklists, reflective prompts, and progress logs—in organizing tasks, enhancing cognitive engagement, and building confidence in students as they navigate research-oriented environments. By supporting autonomy and self-regulation, scaffolding empowers learners to take ownership of their educational journey, bridging the gap between structured guidance and independent achievement.Despite its benefits, challenges remain in optimizing scaffolding for diverse learning needs. Personalized scaffolding approaches are essential to address individual differences in learning contexts, particularly in complex, research-based projects. The integration of digital tools into scaffolding strategies shows promise but requires refinement to ensure usability and practical application. Additionally, while scaffolding promotes short-term engagement, incorporating motivational scaffolds is vital for sustaining focus on long-term goals. This study underscores the need for innovative and adaptive scaffolding designs that balance structure and flexibility, providing educators with practical insights to enhance student autonomy and improve outcomes in higher education settings.

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